

This Page Is Inserted by IFW Operations
and is not a part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

IMAGES ARE BEST AVAILABLE COPY.

As rescanning documents *will not* correct images,
Please do not report the images to the
Image Problem Mailbox.

THIS PAGE BLANK (uspto)

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :

B41C 1/04

A1

(11) International Publication Number:

WO 96/33870

(43) International Publication Date:

31 October 1996 (31.10.96)

(21) International Application Number: PCT/US96/04805

(22) International Filing Date: 5 April 1996 (05.04.96)

(30) Priority Data:

08/431,710

27 April 1995 (27.04.95)

US

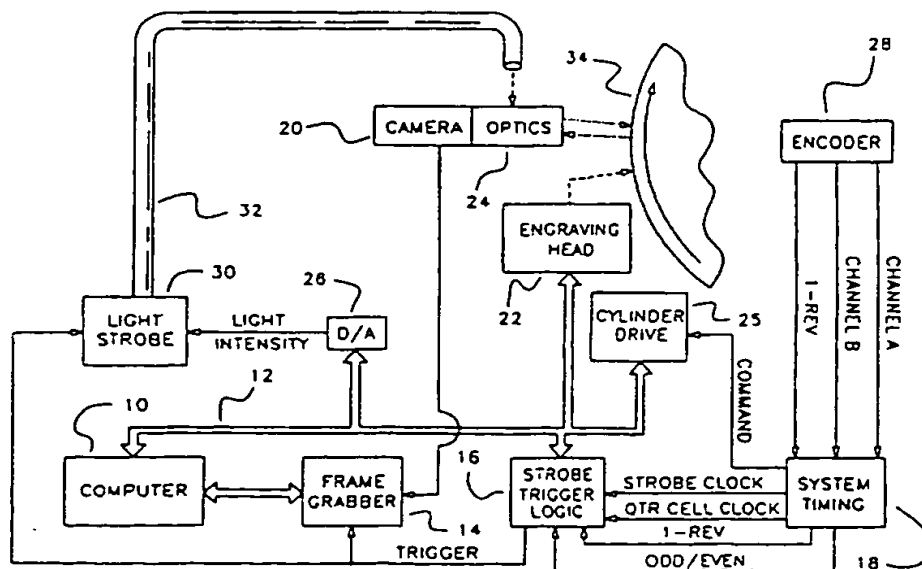
(71) Applicant: OHIO ELECTRONIC ENGRAVERS, INC.
[US/US]; 4105 Executive Drive, Dayton, OH 45430 (US).(72) Inventors: AUBERRY, Eric, R.; Apartment 809, 4460 Bascule
Bridge Drive, Beavercreek, OH 45440 (US). FLANNERY,
David, L.; 4648 Rathbun Drive, Englewood, OH 45322
(US). JACKSON, Kenneth, William; 3922 E. Third Street,
Dayton, OH 45405 (US). SEITZ, David, R.; 1115 Birchton
Place, Vandalia, OH 45377 (US). SERENIUS, Eric, J.; 20
Gerry Court, Springboro, OH 45066 (US).(74) Agents: JENKINS, Matthew, R. et al.; Jacox, Meckstroth &
Jenkins, 2310 Far Hills Building, Dayton, OH 45419-1575
(US).

(81) Designated States: CH, DE, JP.

Published

With international search report.

(54) Title: METHOD OF ENGRAVING A PRINTING SURFACE



(57) Abstract

An engraving system for engraving printings cells in a gravure printing cylinder (34) uses a video camera (20) for feedback control of printing cell width. A setup procedure for the engraving system involves engraving an isolated test cell and a series of adjacent test cells (figure 3), the latter being engraved under steady state engraving conditions. The isolated test cell is located through a search sequence which establishes a strobe control count for a strobe trigger unit (16). The strobe control count then is adjusted for steady state engraving by acquiring and centering a steady state test cell. Cell width is measured by creating video runtable sets for a plurality of overlapping video boxes and finding a maximum connected run length which meets predetermined acceptance criteria.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AM	Armenia	GB	United Kingdom	MW	Malawi
AT	Austria	GE	Georgia	MX	Mexico
AU	Australia	GN	Guinea	NE	Niger
BB	Barbados	GR	Greece	NL	Netherlands
BE	Belgium	HU	Hungary	NO	Norway
BF	Burkina Faso	IE	Ireland	NZ	New Zealand
BG	Bulgaria	IT	Italy	PL	Poland
BJ	Benin	JP	Japan	PT	Portugal
BR	Brazil	KE	Kenya	RO	Romania
BY	Belarus	KG	Kyrgyzstan	RU	Russian Federation
CA	Canada	KP	Democratic People's Republic of Korea	SD	Sudan
CF	Central African Republic	KR	Republic of Korea	SE	Sweden
CG	Congo	KZ	Kazakhstan	SG	Singapore
CH	Switzerland	LJ	Liechtenstein	SI	Slovenia
CI	Côte d'Ivoire	LK	Sri Lanka	SK	Slovakia
CM	Cameroon	LR	Liberia	SN	Senegal
CN	China	LT	Lithuania	SZ	Swaziland
CS	Czechoslovakia	LU	Luxembourg	TD	Chad
CZ	Czech Republic	LV	Latvia	TG	Togo
DE	Germany	MC	Monaco	TJ	Tajikistan
DK	Denmark	MD	Republic of Moldova	TT	Trinidad and Tobago
EE	Estonia	MG	Madagascar	UA	Ukraine
ES	Spain	ML	Mali	UG	Uganda
FI	Finland	MN	Mongolia	US	United States of America
FR	France	MR	Mauritania	UZ	Uzbekistan
GA	Gabon			VN	Viet Nam

-1-

METHOD OF ENGRAVING A PRINTING SURFACE

Cross References to Related Applications

This application is a Continuation-In-Part of Serial No. 08/415,638 filed April 3, 1995, which is a
5 Continuation-In-Part of Serial No. 08/125,938, filed Sept. 23, 1993 which is a Continuation-In-Part of Serial No. 08/038,679 filed March 26, 1993 which is a Continuation-In-Part of Serial No. 022,127 filed Feb. 25, 1992 and a Continuation-In-Part of Serial No. 08/242,012
10 filed May 12, 1994, all of which are incorporated herein by reference and made a part hereof.

Background of the Invention

This invention relates to the field of engraving and more particularly to engraving of gravure
15 printing surfaces, such as gravure printing cylinders. Even more particularly this invention relates to diamond stylus engravers which use video cameras for feedback control of a cell dimension, as disclosed in copending application Ser. No. 08/125,938.

20 In closed loop engraving of the type disclosed in Ser. No. 08/125,938 it is necessary for the video system to generate high resolution images of previously engraved cells for accurate measurement thereof. High resolution imaging may imply a relatively high degree of
25 optical magnification and a correspondingly narrow range of focus. Unfortunately the curvature of a gravure printing cylinder inhibits a sharp focus except within a relatively narrow strip extending in the axial direction along the surface of the cylinder.

30 Before a cell can be measured, it must be identified and positioned inside the sharply focussed

portion of the video image. When the magnification and focus are adjusted for the required measurement accuracy, the optical field of view becomes quite small. This makes it difficult to find a cell which is to be
5 measured.

The problem is further complicated by the rotation of the printing cylinder which proceeds in synchronism with oscillating radial motion of the engraving stylus. The video camera must be strobed at
10 the correct phase to place the relevant cell within the confines of the narrow focussed strip. This phase is established during a setup procedure involving the engraving of a pattern of test cells. However, until a
15 predetermined cell has been placed within the finely focussed strip, it is difficult to know how the phase should be adjusted. As a consequence, correct strobing phase adjustment can become a trial and error process.

Another problem with such closed loop engraving occurs when optically visible defects appear in the image
20 of a cell being examined. Such defects may manifest themselves in the form of cell wall breaks or images of non-existent islands within a region of observation. These defects can lead to incorrect measurements, thereby causing the controller to make erroneous adjustments in
25 the engraving setup.

Summary of the Invention

This invention provides closed loop engraving having improved video tracking capability. The improvement resides in a single cell acquisition
30 technique and in a cell measurement technique which analyzes video run length data within a plurality of differently defined boxes.

-3-

As practiced in this invention, single cell acquisition begins by positioning a video camera adjacent the printing surface and adjusting the focus thereof for high resolution imaging of at least an axially extending narrow strip. Next, an engraving tool is operated to engrave a pattern of test cells in the printing surface. This pattern includes an isolated cell and a series of adjacent test cells sufficient in number to achieve steady state engraving. The isolated cell is sufficiently remote from any other cell to assure that it cannot appear in the same video image with any other engraved cell.

There is a subcell clock which controls the movement of the engraving tool, so that the system always knows the instantaneous angular position of a previously engraved cell, relative to the engraving tool. That relative position of the isolated cell is added to the estimated offset of the camera relative to the engraving tool to provide an estimated instantaneous angular position of the cell relative to the field of view of the camera. The camera is strobed to generate an image when the isolated cell is estimated to be at the center of the field of view. While this may not successfully image the isolated test cell, it does bring the cell sufficiently close to the camera for location by a vertical search.

If the cell does not immediately appear, the system adjusts a strobe control count which controls the phase of the video strobe and commences searching for the cell. A series of small phase adjustments are made, and a new video frame is triggered for each. The search continues until the cell is found. Then the strobe control count is adjusted to place the centroid of the cell at the center of the focussed strip.

After the image of the isolated cell has been centered within the focussed strip, the strobe control

count is adjusted to account for the known offset between the isolated cell and another cell engraved under steady state conditions. This brings the other cell into the field of view of the camera. After that has been
5 accomplished the strobe control count is adjusted for steady state operation by making a correction which will center the steady state cell within the focussed strip. The system then is ready to make accurate measurements of cell dimensions. The dimensions, so measured, may be
10 used to compute engraving errors for closed loop adjustment of production engraving.

Measurement of a cell dimension is accomplished by processing a video image of the cell and generating a plurality of sets of runtables. Each set of runtables
15 consists of run lengths for binary video information within a series of adjacent raster lines collectively defining a box. The boxes for the different sets of runtables cover different portions of the video image and may be partially or fully overlapping.

20 The system knows the approximate size of the cell dimension being measured and uses this knowledge to set limits for a maximum connected video run length. Measurement of a cell feature having the dimension of interest is accomplished by examining the runtable sets
25 and finding a maximum connected video run length which falls between the established limits. That run length is used as a measure of the cell dimension.

Brief Description of the Drawings

Fig. 1 is a block diagram of the engraving
30 system of this invention.

Fig. 2 is a schematic illustration of an offset between an engraving tool and a video camera.

-5-

Fig. 3 is an illustration of an engraving test pattern.

Figs. 4A and 4B illustrate movement of a video image in response to a phase change in a video strobe.

5 Fig. 5 illustrates transient and steady state motion of an engraving tool.

Fig. 6 illustrates the positioning of engraved cells resulting from engraving action as illustrated in Fig. 5.

10 Fig. 7 illustrates a strobe register.

Fig. 8 is a timing diagram for video strobing.

Figs. 9A and 9B are a flow chart illustrating the method of this invention.

15 Fig. 10 illustrates a set of boxes for calculating connected video run lengths.

Fig. 11 illustrates box positioning within a field of cells.

Description of the Preferred Embodiment

Referring now to Fig. 1, there is illustrated a
20 block diagram of a system according to the present invention. The system includes a computer 10 connected to a bus line 12 for communication with a frame grabber 14, a strobe trigger unit 16, a system timing unit 18, an engraving head 22, a cylinder drive unit 25 and a
25 digital-to-analog converter 26. Engraving head 22 operates under control of computer 10 to engrave the surface of a gravure printing cylinder 34 which is axially rotated by the drive unit 25.

30 Drive unit 25 and engraving head 22 operate at a subcell clock frequency. Encoder 28 monitors the rotation of cylinder 34 and generates two channels of data which define the subcell clock. The subcell clock may be generated at any multiple of the cell engraving

frequency. The implementation hereinafter described uses quarter cell clock pulses, four of which are generated for each cycle of engraving head motion. Encoder 28 transmits the subcell clock and a 1-REV signal to a timing unit 18. The 1-REV signal is an index signal which is pulsed once for each revolution of printing cylinder 34.

Timing unit 18 includes a frequency multiplier, which may take the form of a phase locked loop, connected for generating a strobe clock at an appropriate frequency. Preferably, the strobe clock is generated by multiplying a quarter cell clock by a factor of 40. Timing unit 18 sends the strobe clock, as well as the quarter cell clock, an ODD/EVEN revolution indication and the 1-REV signal to strobe trigger logic 16. These three signals are placed on bus 12 for transmission to computer 10 in the form of interrupts. Computer 10 then calculates a strobe control count, as hereinafter described, which is loaded into a strobe register 93 (Fig. 7) situated within the strobe trigger logic 16. Strobe register 93 generates trigger pulses to activate a light strobe 30, the intensity of which is controlled by D/A 26. Light strobe 30 directs a beam of light along a fiber optic cable 32 and into an optics unit 24. Trigger pulses from strobe register 93 are also supplied to frame grabber 14.

Optics unit 24 illuminates cells which are engraved into the surface of cylinder 34 by engraving head 22 and projects images of those cells onto a CCD array (not illustrated) in a video camera 20. Camera 20 creates rastered video frames which are selectively read by frame grabber 14 and stored in computer 10 in response to the trigger pulses from strobe register 93. Optics unit 24 may be focussed manually for high resolution imaging of the surface of cylinder 34. Preferably,

- 7 -

however, camera 20 includes an auto focus unit (not illustrated) of the type described in copending application serial number (Docket No. OEE 061 P2). Such an auto focus unit focusses the optics 24 upon surface scratches within a narrow strip extending axially along cylinder 34.

Fig. 2 illustrates the spatial relationship between optics unit 24 and an engraving stylus 40 during scanning of cylinder 34 by camera 20 and optics 24. It can be seen that the optics produce an image of a location on the surface of cylinder 34 which is offset from the position of cutting tool 40 by a distance D. Because of this offset, camera 20 must wait a short period of time before imaging a newly engraved cell. This time delay, hereinafter termed a "transit time" may be calculated by dividing the distance D by the surface speed of cylinder 34. This is a one-time calculation which is held fixed by appropriate fixturing. The transit time calculation is converted to subcell counts and saved in memory.

As stated previously, engraving head 22 engraves the surface of cylinder 34 under control of computer 10. All engraving is synchronized by the 1-REV signal. Each cell is assigned a row location and is tagged with a subcell count which corresponds to the assigned row. The cell is engraved at a predetermined point in time established by counting subcell pulses which occur following a 1-REV signal. The subcell count associated with any given cell establishes the rotational phase of that cell relative to the index point on the printing cylinder. This phase count may be added to the above discussed transit time count to establish the point in time when an engraved cell is expected to pass through the field of view of video camera 20. With this information the system is able to activate light strobe

- 8 -

30 at the correct time for locating and imaging any
predetermined cell. Positioning of the image within a
video frame is refined by converting the subcell count to
strobe control count, and adding a correction count, as
5 will now be described.

Determination of a correction count commences
by engraving a test block 50, as illustrated in Fig. 3.
Test block 50 includes a first isolated test cell 52, a
second isolated test cell 54 and a series of adjacent
10 test cells 56. The series of test cells 56 includes
cells 56a through 56e.

The engraving of isolated test cells 52, 54,
and the first few cells of the series 56, is accompanied
by transient motion of engraving stylus 40. However, the
15 stylus has achieved a fairly steady state motion by the
time it engraves cells 56d and 56e. Cells 52, 54 are
sufficiently isolated to prevent any other cells, such as
cells within the illustrated row 51 from appearing in the
same video frame with either of cells 52 or 54.

20 After the test pattern 50 has been engraved,
video camera 20 is strobed at a phase for placing
isolated cell 52 approximately within the field of view
of the camera. This approximate phase is determined in
the manner described above. Then the cell is located and
25 positioned as hereinafter described in detail with
reference to Figs. 9A and 9B.

Figs. 4A and 4B illustrate the final phases of
a typical positioning adjustment. Shown therein is a
video frame 60 including a strip 58 wherein the image
30 information is well focussed. Appearing in video frame
60 is a representation 56 of isolated cell 52. In Fig.
4A the video representation 56 is slightly outside the
region of focus 58. The positioning of the
representation 56 indicates that there is too much delay.
35 Fig. 4B illustrates a position of the representation 56

-9-

after the appropriate incremental delay has been subtracted.

After the strobing phase has been adjusted as illustrated in Fig. 4B, the system has an appropriate
5 transit time correction to account for the offset of camera 20. However, the use of an isolated cell to make that correction introduces a small error due to transient operation of the engraving tool 40. This is illustrated in Fig. 5.

10 Shown in Fig. 5 is a smooth sinusoidal line 70 which represents the movement of an engraving stylus during steady state engraving. This line oscillates between values of 0 and 255. Three wave lengths 70a, 70b and 70c are illustrated. Juxtaposed alongside line 70 is
15 another line 72 illustrating the motion of engraving stylus 40 during engraving of an isolated cell. The line 72 crosses the 0 and 255 levels at times which are phase shifted relative to the corresponding points 80, 82, 84 of line 70. The amount of phase shift is indicated by
20 the arrows 74, 74, 74. This phase shift produces an error which must be removed. Fig. 6 illustrates the corresponding positioning of an isolated cell 92 and three steady state cells 90b, 90c and 90d, all engraved by signals as illustrated in Fig. 5. Also shown on Fig.
25 6 are two additional steady state cells 90a and 90e

Fig. 7 illustrates the input and output lines for a strobe register 93. Strobe register 93 is clocked by the strobe clock, which as stated above, is 40 times faster than the quarter cell clock. A strobe
30 control count is loaded into the register as appropriate for achieving the desired image positioning. A 1-REV trigger initiates a counting operation in register 93. During this counting operation register 93 counts strobe clock pulses until the strobe control count has been
35 reduced to zero. At that point the register generates a

trigger signal. A timing diagram illustrating a 1-REV pulse 94, a trigger pulse 96 and a strobe clock signal is presented in Fig.8.

Referring now to Figs. 9A and 9B, the method of
5 this invention commences at entry point 102 and proceeds with camera focussing (block 104). Then, at block 105, the camera (also the optics and the engraving stylus) is moved in the axial direction (perpendicular to the plane of Fig. 1) an appropriate distance for moving the camera
10 field of view away from any previously engraved cells, such as the cells 51 of Fig. 3. In this regard it will be appreciated that camera 20 and optics 24 are supported by a carriage which is driven in the axial direction by a lead screw. The same lead screw provides axial
15 movement for engraving head 22. The lead screw and the carriage structure are conventional and are not illustrated in the drawing.

During production engraving the lead screw rotates in synchronism with the rotation of cylinder 34, so that camera 20, optics 24 and engraving head 22
20 progress axially along cylinder 34 in synchronism with cylinder rotation. This causes printing cells to be engraved along a helical track which progresses along the length of the cylinder. Alternatively, the lead screw
25 may be driven in a stepped fashion to produce circumferential engraving, as is well known in the art.

In the practice of this invention it is necessary for the camera to dwell on an isolated cell and to observe the vertical movement of that cell within the
30 camera field of view, as the phase of the strobe signal is adjusted. It is desired that the camera not move in the axial direction during such adjustment. It is further desirable that the camera and the engraving stylus remain at a fixed axial location after completion
35 of the movement indicated by block 105. In the preferred

-11-

embodiment the lead screw is motionless during the series of steps following block 105, but printing cylinder 34 continues to rotate.

After the camera 20 and optics 24 have been positioned the method proceeds to block 106 where engraving stylus 40 is activated to cut the test pattern 50 of Fig. 3. As discussed above, that test pattern includes an isolated cell 52 which is moved into a region of sharp focus 58, as illustrated in Figs. 4A and 4B. This is a two step process. The first step involves a coarse strobe adjustment to place the cell somewhere within the field of view of camera 20. This enables cell location for performance of the second step, which is a fine adjustment of strobe timing.

After the test pattern 50 has been cut, the method proceeds to block 108 where the coarse strobe adjustment begins. At this point computer 10 calculates the subcell delay required for placing isolated cell #1 (cell 52 of Fig 3) in the field of view of camera 20. In general the camera offset count will be known and need only be read from memory. The subcell count for the isolated cell will have been calculated by conventional methods in order to engrave the test pattern and is saved in memory. At block 110 the value of this count is be read from memory for addition to the camera offset count. The resulting count is multiplied by an appropriate factor to convert the quarter cell count to the corresponding strobe control count (block 111). In a typical case that factor may have a value of about 40. The strobe control count is saved for subsequent adjustment.

Block 112 begins a control loop concerned with locating isolated cell #1. Since the cell is isolated, any cell which is imaged in response to the above trigger strobe is known to be cell #1. At that point the stored

-12-

value of the strobe control count is loaded into strobe register 93. The strobe register performs a down count and generates a trigger strobe (block 114).

5 The generation of a trigger strobe produces a video frame which is grabbed by frame grabber 14. This frame either does or does not contain an image of cell #1. At point 116 computer 10 checks the frame to determine whether a cell image is present. If so, then the program proceeds to block 132 of Fig. 9B.

10 If cell #1 is not immediately found then the program branches at point 118 to block 120 wherein the strobe control count is decreased by a number sufficient to produce 240 microns of movement. Then the program returns to block 112 and loads strobe register 93 with
15 the decreased count value for triggering a repositioned video frame.

If cell #1 does not appear in the second frame, then the program branches to block 126, adds a 60 micron count to the strobe control value and triggers another
20 video frame. The program continues looping through block 126 and looking for the cell until it is found or until there have been 9 passes through block 126. Upon exiting block 126 for the 9th time the program passes through branch point 124 to an error exit point 130. At this
25 point the system will have scanned a vertical height of 480 microns, and this is taken as an indication that something has gone wrong.

After cell #1 has been found, the fine strobe adjustment step begins. Accordingly, the program
30 proceeds to block #132 for locating the center of the cell. The cell center is located by a measurement technique as hereinafter described with reference to Fig. 10. Since the measurement is made before the cell is positioned within the finely focussed strip 58 of video
35 frame 60, an accurate cell measurement cannot be made.

-13-

However, the measurement is sufficiently accurate for determining the distance between the center of the cell and the center of the video frame. The vertical component of this distance is converted to an equivalent
5 strobe count which is added to the stored strobe control count. The newly corrected value of the count is loaded into strobe register 93 at block 134, and a new video frame is triggered. This centers the cell in the video frame for an accurate measurement, which is performed at
10 block 136.

As described below the measurement technique makes three measurement attempts within three different, preferably overlapping, measurement boxes. If measurement is unsuccessful, then the program passes
15 through branch point 138 to an error exit 140.

If cell #1 is successfully measured, then the program branches to block 142 and measures isolated cell #2 (cell 54 of Fig. 3). This involves adjustment of the strobe control count to reflect a subcell positional
20 separation between cell #1 and cell #2. This subcell difference is precisely known, and therefore strobe register 93 should trigger a video frame including an image of cell #2 which is vertically centered within the finely focussed strip 58. Cell #2 is measured at block
25 142 as a check upon the previous measurement of cell #1.

If cell #2 is not successfully measured, then the program passes through branch point 144 to an error exit at point 146.

If cell #2 is successfully measured, then the
30 program proceeds to block 148 to commence a correction for the transient phase shift associated with engraving of an isolated cell. This involves measuring a cell such as cell 56d of Fig. 3 which is known to have been engraved under steady state conditions. The required
35 correction for the strobe control count is determined by

-14-

first adding the strobe count of the offset between cells 54 and 56d. Then strobe register 93 is activated to trigger a video frame containing an image of the steady state cell. This cell will appear with a vertical error
5 as indicated in Fig. 6. The error is measured at block 150 and converted to an equivalent strobe count. That equivalent strobe count will be just the right size for removing the transient error from the strobe control count. Assuming that the steady state cell is
10 successfully measured, the transient correction count is added to the strobe control count, and the process proceeds to a termination point 156. An unsuccessful effort to measure the steady state cell 56d causes the program to pass through branch point 52 and into an error
15 exit 154.

It will be understood that the method of this invention may be used for locating and measuring any cell dimension of interest, provided that the relative position of a "centered" aiming point is known, and
20 further provided that an approximate size for the dimension is known. This enables construction of a box encasing the dimension and centered within the region of sharpest focus. This is illustrated by a box 250 in Fig. 11.

25 As shown in Fig. 11, box 250 straddles the width of one several engraved cells 260. The measurement technique of this invention only considers information within a predefined portion of a video frame, such as, for instance box 250. This rejects noise and increases
30 the probability of an accurate measurement.

Referring now to Fig. 10, the cell measuring method of this invention will be explained. However, this requires a brief discussion of binary imaging. Binary images may be efficiently encoded in chord tables
35 (sometimes called run-length encoding). The tables

-15-

organize the chords by rows, and from left-to-right within each row. Each chord entry in a table consists of the starting column and ending column of the chord. An alternate representation uses vertical (column aligned) chords organized by columns and encodes the starting and ending rows of each chord. The encoded chords may represent either the white or dark pixels of the binary image; either representation is complete. An efficient algorithm for segmenting connected regions in chord-encoded binary images is well known. See "The Image Processing Handbook" by John C. Russ, CRC Press, 1992, especially pages 286-287 thereof. In this method, each chord is assigned a label which is unique to a segmented region.

For simplicity and clarity, the following discussion will assume horizontally-aligned (row-organized) chords encoding the white pixels. Fig. 10 schematically depicts a binary image of the type upon which measurements are to be made. The image might be derived from a micro-photograph of the engraved copper surface of a printing cylinder used in a roto-gravure printing machine. In the figure the thick curved lines 210, 212 represent the walls of engraved printing cells and the desired measurements are the cell width, labeled 'W' in the figure, and the channel width, labeled 'C' in the figure. Two types of image defects that impede the desired measurements are blobs 204, 206 called "islands" and cell wall breaks, such as break 214 in cell wall 210.

In an ideal image, i.e., without the islands and breaks, the chord-labeling procedure referenced above would easily segment the image into connected regions 201, 202 and 203 and measurement of the desired features could be easily performed by searching (in the chord table) each labeled region for a maximum region-width (for cell width measurements) or for a minimum region-

-16-

width (for channel width measurements). As taught in the Russ reference, the maximum width of a connected region is determined by examining the chord tables for overlapping runs in adjacent scan lines and aggregating the minimum and maximum column numbers where overlap is observed.

The six horizontal lines pair-wise marked 'X', 'Y', and 'Z' in the above figure represent the top and bottom walls of three possible choices of boxes over which sets of chord-encoded representations (called "runtables") of the image scan lines therein might be formed for the purpose of measuring the features. In the absence of the islands 204, 206 and wall break 214, the segmentation process would produce the same three connected regions for each choice of vertical extent for a runtable box, and three identical cell width and channel width measurements would be obtained.

With the islands and wall break present as indicated in Fig. 10, it may be seen that the region segmentation required to support valid measurements is obtained for only one of the three choices of vertical extent, specifically for the box defined by the two lines marked Y. If the vertical extent defined by the lines marked Z is used, the wall break 214 connects regions 202 and 203 into a single region, precluding successful measurement. For the vertical extent defined by the lines marked X, the islands cause region 202 to separate into two distinct connected regions, and they cause region 203 to break into three regions, again precluding valid measurements.

The measuring method of this invention determines the width of a cell feature by preparing sets of runtables for a plurality of overlapping boxes which collectively bracket the area of interest. Each of these sets of runtables is examined to determine a maximum

connected run length . The maximum connected run lengths, so determined, are compared against maximum and minimum expected values thereof. Any maximum connected run length which meets the established requirements may
5 be used as the measured width. If no maximum connected run length meets the established run length limits, then a measurement failure is declared.

It will be appreciated that more or less than three measurement boxes may be selected and that features
10 other than cell width and channel width may be measured, provided that the measurement boxes are maintained within the finely focussed strip running horizontally across the video frame. This frame generally occupies the middle third of the video frame and, in a typical case spans a
15 region slightly larger than the region illustrated in Fig. 10.

It is contemplated that the method of this invention may be used for measuring the lengths of a series of adjacent strips across an engraved cell. These
20 strip lengths may be totalled and multiplied by the strip width to provide a measure of the cell area. Such a cell area measurement may be made during production printing and used as an indication of cylinder wear. As gravure printing cylinders are used, the surface wear decreases
25 the area of the engraved cells. As the wear continues, there comes a time when cylinder replacement becomes necessary. This invention provides a method for accomplishing that replacement on a timely basis.

While the method herein described, and the form
30 of apparatus for carrying this method into effect, constitute preferred embodiments of this invention, it is to be understood that the invention is not limited to this precise method and form of apparatus, and that changes may be made in either without departing from the

-18-

scope of the invention, which is defined in the appended claims.

What is claimed is:

1. Method of calibrating an engraver to engrave cells in a moving surface comprising the steps of:

(1) engraving an isolated cell into said moving surface;

5 (2) generating a video image of said isolated cell by strobing a video camera at a calculated phase relative to movement of said surface;

10 (3) using said video image of said isolated cell to determine an error in said calculated phase;

(4) generating video images of other cells in said surface by strobing said video camera at calculated phases which are adjusted in
15 accordance with said error; and

(5) using said images of said other cells to calibrate said engraver.

2. Method of calibrating a gravure engraver comprising the steps of:

(1) engraving an isolated test cell;

(2) generating a video image of said isolated test cell;

(3) engraving a series of adjacent test cells, including a test cell having steady state characteristics;

(4) using said video image of said isolated test cell to generate a video image of said test cell having steady state characteristics; and

(5) using said last mentioned video image to calibrate said engraver.

-20-

3. Method of measuring a dimension of a cell on a printing cylinder comprising the steps of:

(1) positioning a video camera alongside said printing cylinder, said video camera being responsive to a strobe signal for generating a video image of a portion of said printing cylinder which happens to be facing said video camera at the time of said strobe signal;

(2) axially rotating said printing cylinder;

(3) engraving an isolated cell into said printing cylinder;

(4) applying said strobe signal to said video camera at a phase relative to said rotating such that said isolated cell is positioned for inclusion in a said video image resulting therefrom,

(5) using said video image to establish a positioning error for said isolated cell;

(6) using said positioning error to calculate a correction value for said phase;

(7) generating a video image of another cell by applying to said video camera a said strobe signal which is corrected in accordance with said correction value; and

(8) using said video image for measuring a dimension of said another cell.

4. Method according to claim 3 further comprising the steps of engraving and imaging a second isolated cell for verification of said positioning error.

- 21 -

5. Method of operating an engraver to engrave printing cells in the surface of a gravure printing cylinder comprising the steps of:

5 (1) positioning a video camera alongside said surface for generating video images of portions of said surface;

10 (2) focussing said video camera so that each of said video images includes a high resolution representation of a strip extending axially along said surface;

15 (3) positioning an engraving stylus alongside said surface at a known axial displacement from said video camera and circumferentially displaced therefrom by a determinable offset distance;

(4) determining the amount of said offset distance;

20 (5) axially rotating said printing cylinder so that said surface attains a predetermined circumferential speed;

(6) calculating a transit time required for a point on said surface to rotate from a position adjacent said stylus to a position for imaging by said video camera;

25 (7) operating said engraver at a predetermined time for causing said stylus to engrave an isolated test cell in said surface;

30 (8) generating an image of a portion of said surface by strobing said video camera in synchronism with rotation of said printing cylinder and at a phase corresponding to said transit time;

35 (9) adjusting said phase to a first adjusted value thereof, so that said image of a portion of said surface includes a video

-22-

representation of said isolated test cell positioned within said strip;

40 (10) operating said engraver for causing said stylus to engrave a string of test cells in said surface, including a steady state test cell engraved after a steady state engraving condition has been achieved;

45 (11) generating an image of said steady state test cell by strobing said video camera in synchronism with rotation of said printing cylinder and again at a second adjusted value of said phase, said second adjusted value being shifted from said first adjusted value in accordance with an offset distance between said
50 isolated test cell and said steady state test cell;

(12) moving said image of said steady state test cell to a predetermined position within said strip by adjusting said phase to a
55 third adjusted value thereof;

(13) operating said engraver for causing said stylus to engrave a series of production cells in said surface;

60 (14) using said third adjusted value of said phase for strobing said video camera to generate images of said production cells;

(15) processing said images of said production cells to measure errors therein; and

(16) adjusting said engraver to decrease said errors.

6. A method of measuring a dimension of an engraved printing cell comprising the steps of:
generating a video image of said cell; and
generating a plurality of sets of runtables for
5 video information within a plurality of sets of adjacent scan video scan lines selected from said image.

7. Method of engraving a gravure printing surface
10 comprising the steps of:

(1) generating a cell dimension control signal;

(2) using said cell dimension control signal for engraving a printing cell into said
15 surface;

(3) generating a rastered video image of said cell;

(4) generating a plurality of sets of runtables for video information incorporated
20 within said image, said sets of runtables being extracted from video information within boxes defined by different sets of consecutively adjacent scan lines;

(5) establishing maximum and minimum
25 limits for said width and corresponding maximum and minimum values of connected video run lengths;

(6) calculating connected video run
30 lengths for said sets of runtables until a calculated video run length is found which is between said maximum and minimum values; and

(7) using said calculated video run length for adjusting said cell width control signal.

8. A method of imaging an engraved area on a cylinder comprising the steps of:
imaging a portion of a surface of the cylinder with an imager; and
5 registering said engraved area within a region of focus of said imager.
9. The method as recited in claim 8, further comprising the step of:
scanning image data generally corresponding to said portion.
10. The method as recited in claim 9 wherein said engraved area is at least one cell, said method further comprising the step of:
isolating said cell within said region of focus.
11. The method as recited in claim 9 wherein said engraved area is a cell.
12. The method as recited in claim 10 wherein said engraved area is a scratch on said surface of said cylinder.
13. The method as recited in claim 8, further comprising:
identifying said engraved area prior to said imaging step.
14. The method as recited in claim 13 wherein said engraved area is a cell.

15. The method as recited in claim 8 wherein said imager is associated with a stylus on said engraver, said method further comprising the step of:

determining an offset generally corresponding
5 to a distance between said stylus and said imager.

16. The method as recited in claim 15 wherein said method is performed during real-time operation of the engraver.

17. The method as recited in claim 8 wherein said method is performed during real-time operation of the engraver.

18. The method as recited in claim 8, further comprising:

focusing said imager on said portion.

19. The method as recited in claim 8, further comprising:

measuring said engraved area.

20. The method as recited in claim 19 wherein said engraved area comprises at least one cell.

21. The method as recited in claim 8 wherein said engraved area comprises a plurality of cells.

22. The method as recited in claim 8, further comprising:

identifying a test cell;

strobing said portion with a strobe;

5 determining if said test cell falls within said region of focus.

23. The method as recited in claim 22, further comprising the step of:
determining a second offset if said test cell is not centered within said region of focus.
24. The method as recited in claim 23, further comprising the step of:
timing said strobe to adjust for said second offset.
25. The method as recited in claim 24, further comprising the step of:
performing said timing during real-time operation of the engraver.
26. The method as recited in claim 8, further comprising the step of:
timing said strobe to adjust for said second offset.
27. The method as recited in claim 26, further comprising the step of:
performing said timing during real-time operation of the engraver.
28. The method as recited in claim 27, further comprising the step of:
measuring said engraved area.
29. The method as recited in claim 28, further comprising the step of:
automatically focusing on said engraved area.

30. A system for imaging an area on a surface of a cylinder, comprising:

an imager for imaging said area and for generating image data corresponding thereto; and

5 a processor coupled to said imager for processing said data in order to cause at least a portion of said area to be registered within a region of focus of said imager.

31. The system as recited in claim 30, further comprising:

a scanner for scanning said image data.

32. The system as recited in claim 30 wherein said processor further comprises:

5 an isolator for isolating said at least a portion of said area from an non-isolated area of said at least a portion.

33. The system as recited in claim 32 wherein said at least a portion of said area is an engraved cell.

34. The system as recited in claim 32 wherein said at least a portion of said area is a scratch on a surface of said cylinder.

35. The system as recited in claim 30 wherein said processor further comprises a determiner for determining an offset generally corresponding to a distance between said stylus and said imager.

36. The system as recited in claim 30 wherein said system further comprises:

a strobe coupled to said processor for strobing said area to facilitate imaging said area.

37. The system as recited in claim 30 wherein said processor further comprises a timer for timing said imager to facilitate capturing an image of said area.

38. The system as recited in claim 36 wherein said processor further comprises a timer for timing said imager to facilitate capturing an image of said area.

39. The system as recited in claim 30 further comprising:

an autofocuser coupled to said processor for automatically focusing on said surface.

40. The system as recited in claim 30 wherein said processor comprises:

a measurer for receiving said image data and for generating a measurement of said at least a portion
5 of said area.

41. The system as recited in claim 40 wherein said at least a portion is an engraved cell.

42. Method of measuring the area of an engraved printing cell comprising the steps of:

- (1) generating a video image of said cell;
- (2) generating runtables for video information
5 within a plurality of video strips having predetermined widths and collectively covering said image;
- (3) using said runtables to determine lengths for those portions of said strips extending
10 between boundaries of said cell; and
- (4) using said lengths and said widths for calculating said area.

43. A method of determining wear of a surface of a cylindrical surface provided with engraved cells; said method comprising the step of using the method of claim 42 to determine the area of one of said cells.
44. The method as recited in claim 6, further comprising:
establishing limit values for said dimension.
45. The method as recited in claim 6, further comprising:
computing maximum connected run lengths for said sets of runtables.
46. The method as recited in claim 44, further comprising:
identifying one of said maximum connected run lengths having a length corresponding to a value of said dimension within said limit values.
47. A method of measuring comprising the steps of:
generating a video image of an engraved area;
generating at least one runtable for video information within a scanned area of said video image;
and
identifying a first cell using said at least one runtable.
48. A method of measuring comprising the steps of:
generating a video image of an engraved area;
generating a plurality of sets of runtables for video information within a plurality of sets of adjacent scan video scan lines selected from said image; and
selecting of said plurality of sets of runtables to measure a distance of said cell.

49. The method as recited in claim 48, further comprising:
establishing limit values for said dimension.

50. The method as recited in claim 49, further comprising:
identifying one of said maximum connected run lengths having a length corresponding to a value of said dimension within said limit values.

51. A method locating an engraved area on an engraved surface comprising the steps of:
imaging the engraved surface;
locating a first area within said image and generating data corresponding thereto;
locating at least one other area using said data.

52. The method as recited in claim 51, further comprising:
locating an approximate center of said first area.

53. The method as recited in claim 51, further comprising:
generating an offset value corresponding to a relationship between said first area and said at least one other area.

54. The method as recited in claim 51, further comprising:
using said offset value to calibrate an engraving head.

55. The method as recited in claim 51 wherein said first area is a test cut.

56. A method of monitoring engraved areas in a printing press comprising:

imaging said engraved area comprising at least one cell; and

monitoring said engraved area over a period of time to determine if there is a change in dimension of said at least one cell.

57. The method as recited in claim 56, further comprising:

stopping the printing press if said change of dimension is outside a predetermined tolerance range.

58. The method as recited in claim 56, further comprising:

locating a cell in the engraved area using at least one runtable of video information data.

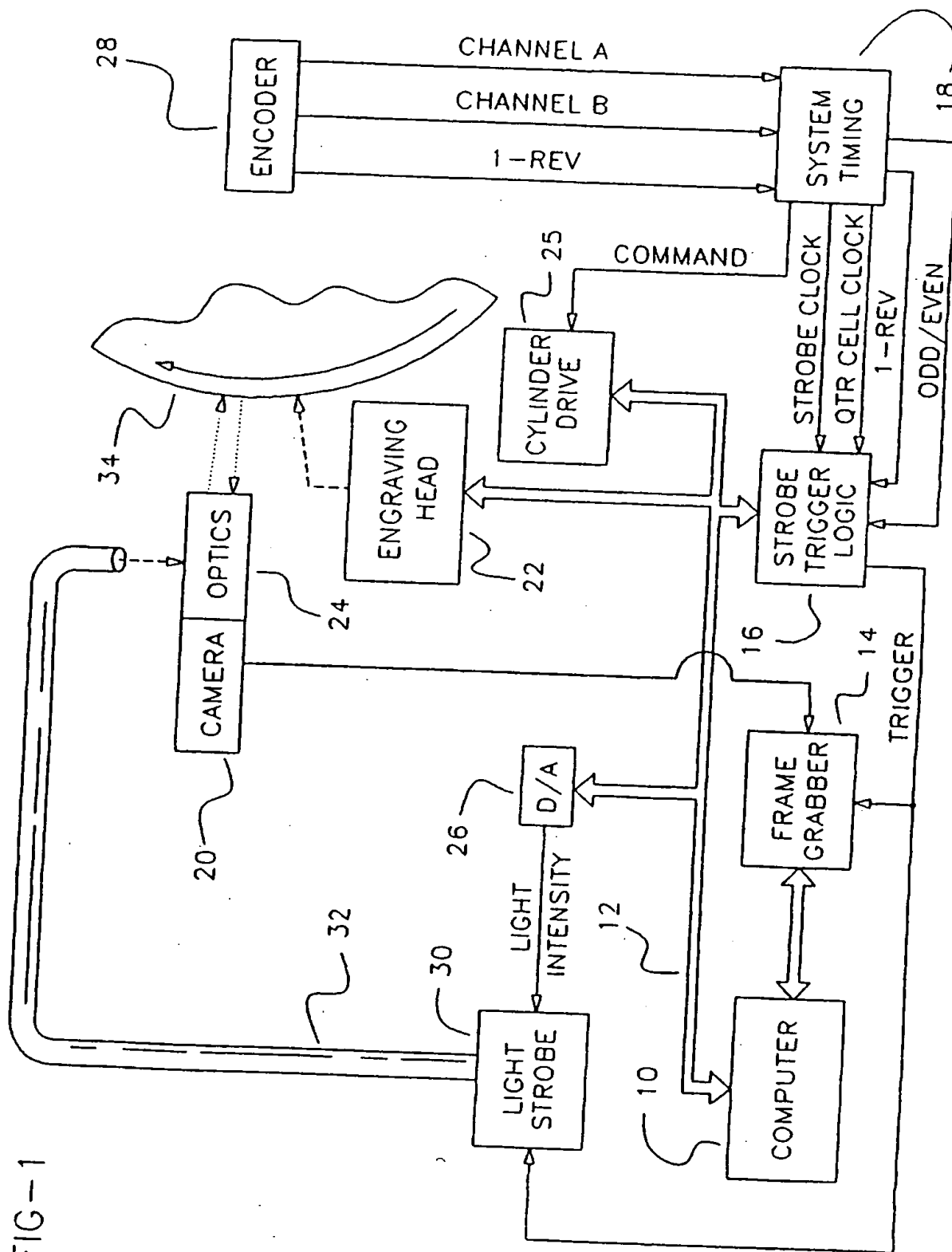


FIG-1

FIG-2

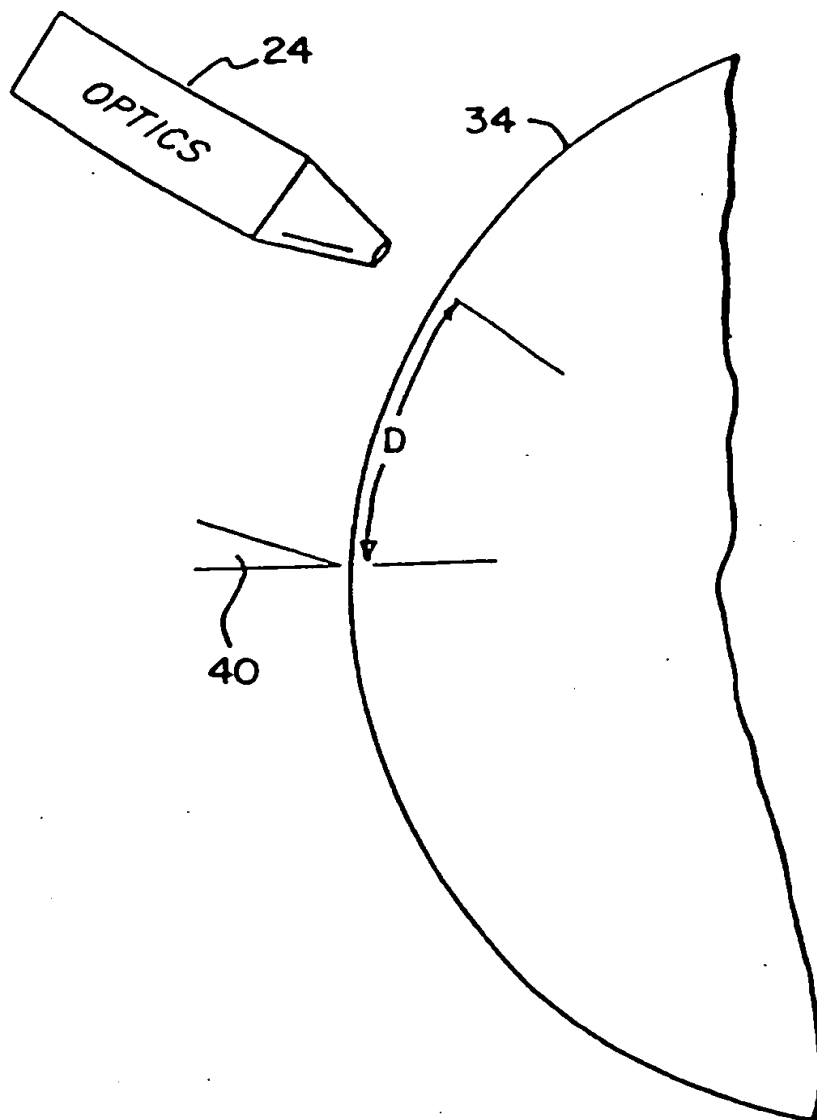


FIG-3

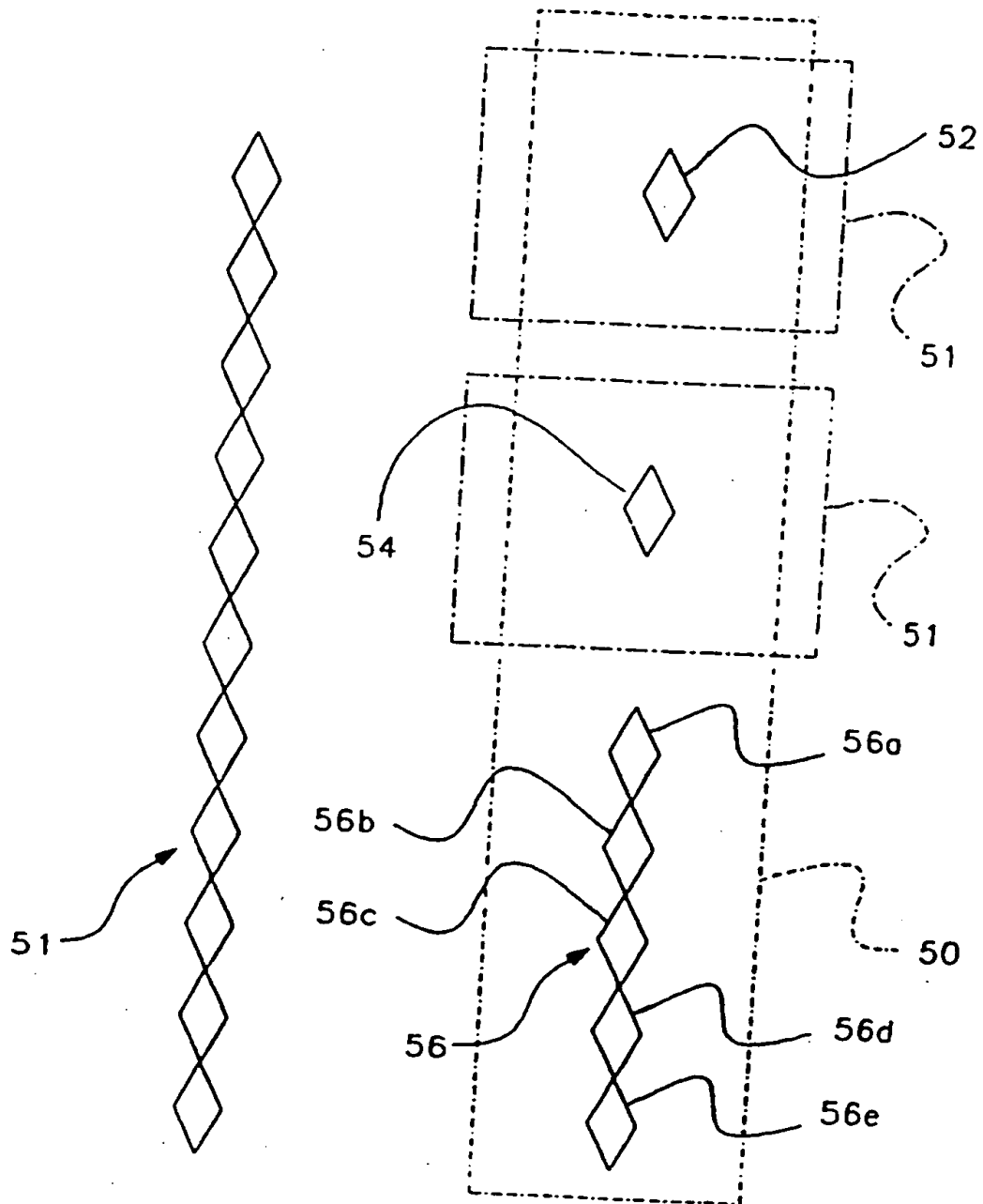


FIG-4B

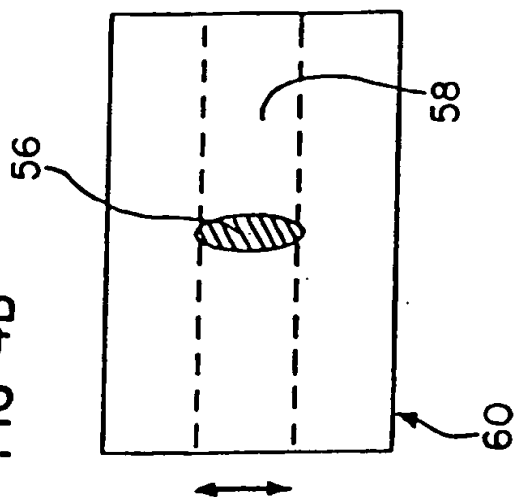


FIG-4A

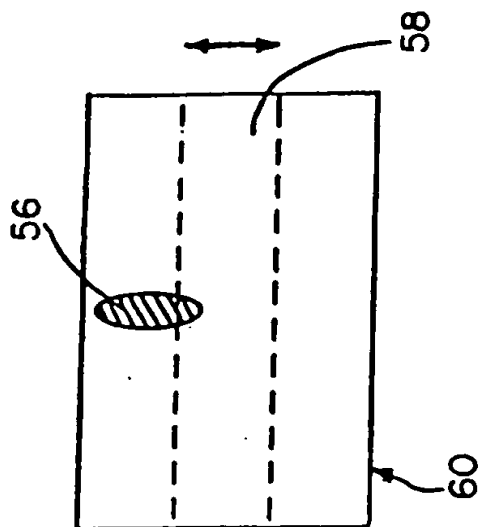


FIG-5

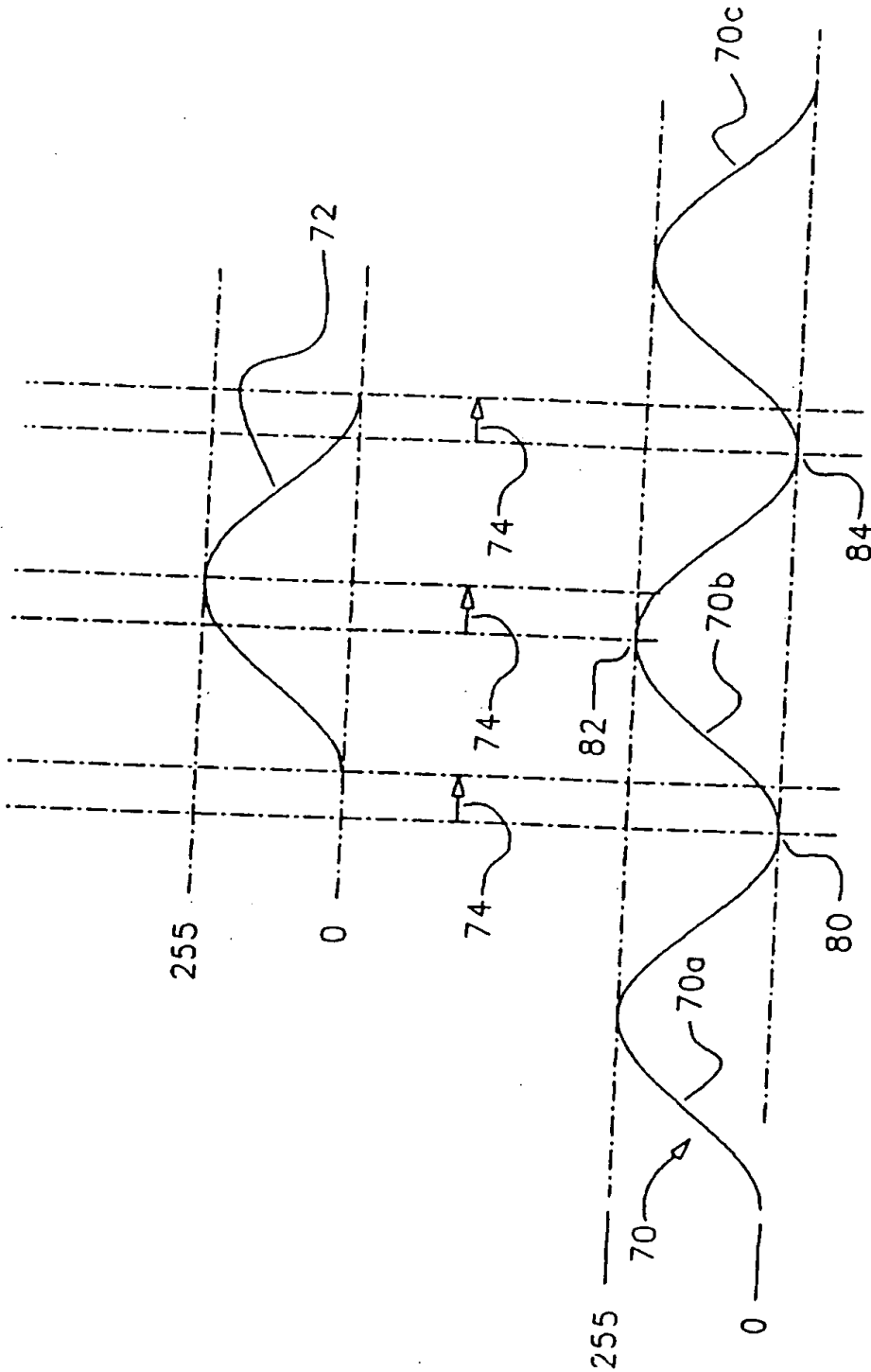


FIG-6

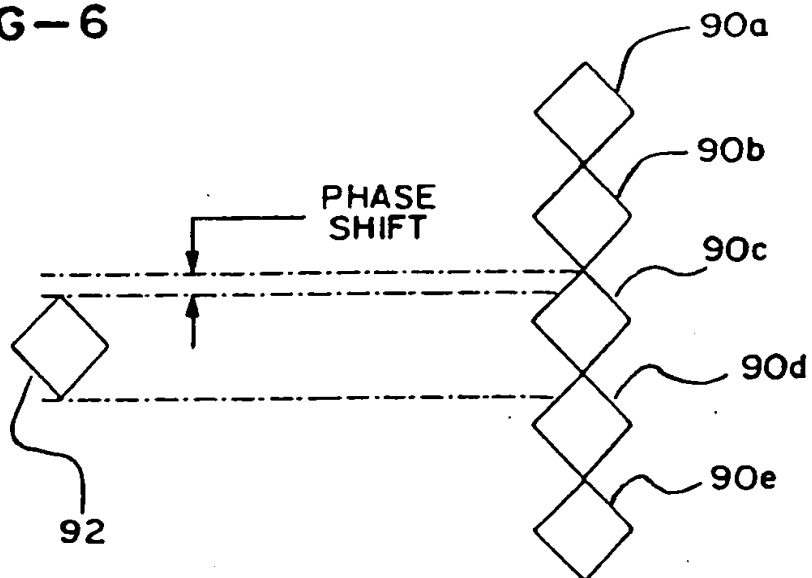


FIG - 10

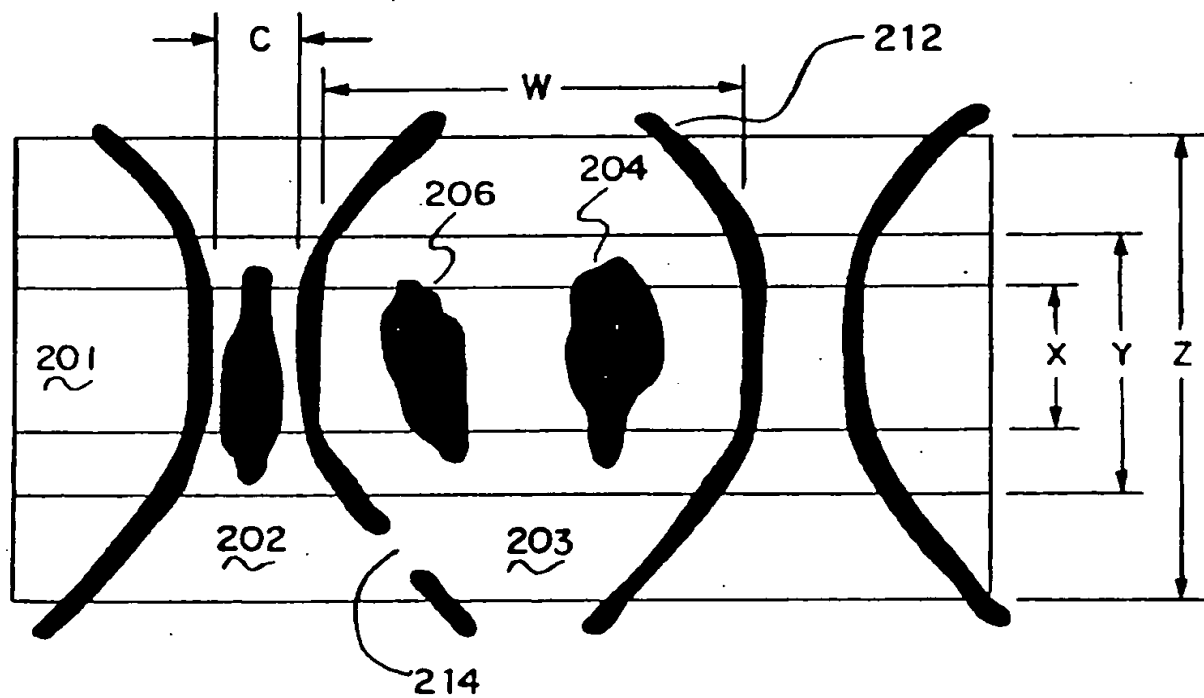
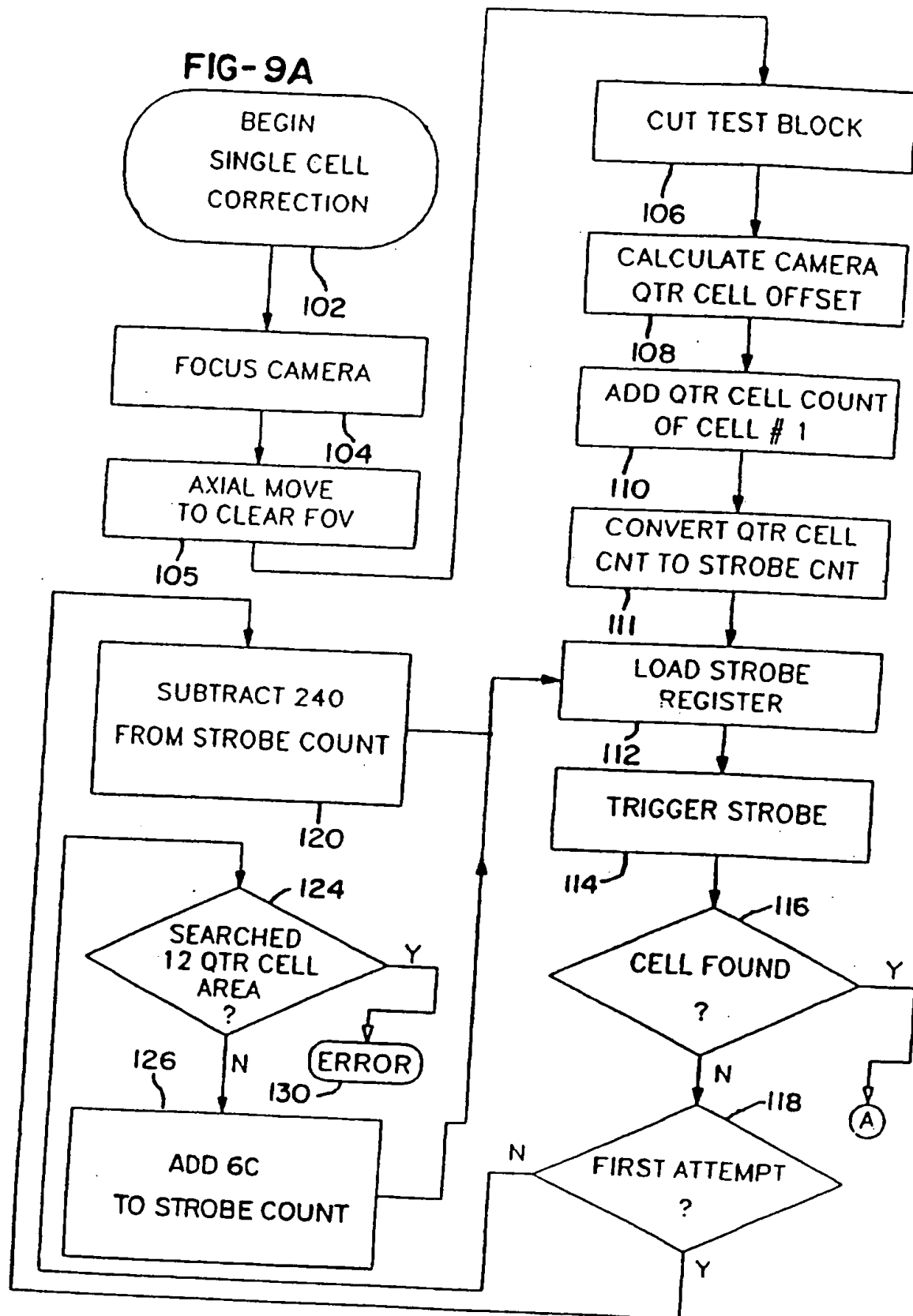


FIG-9A



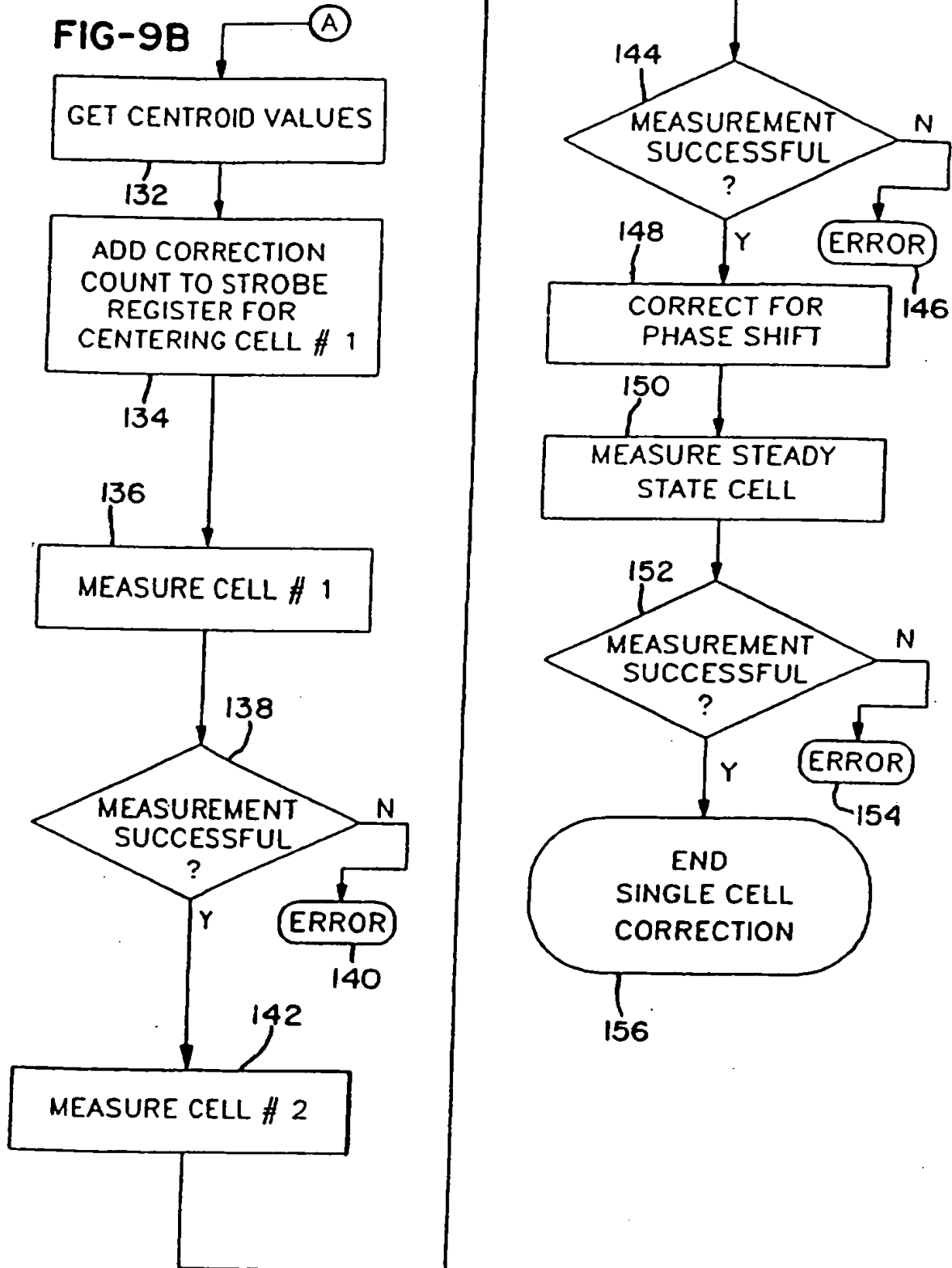


FIG-11

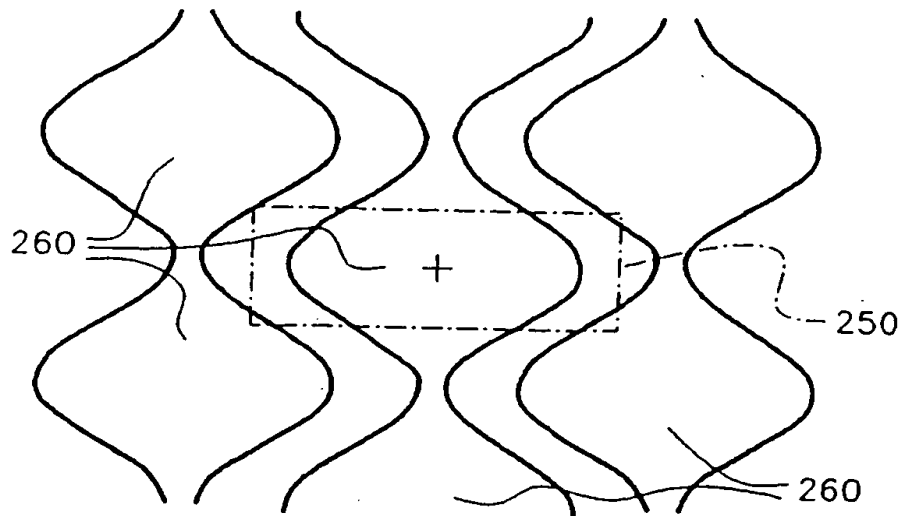


FIG-7

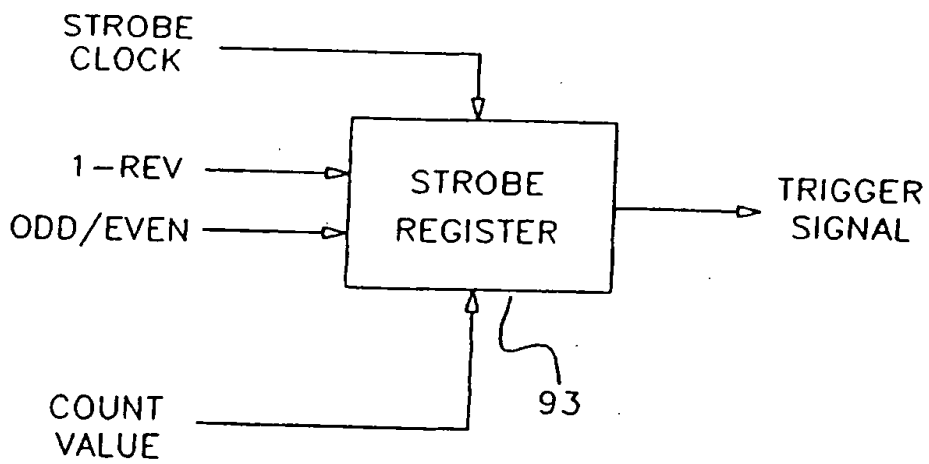
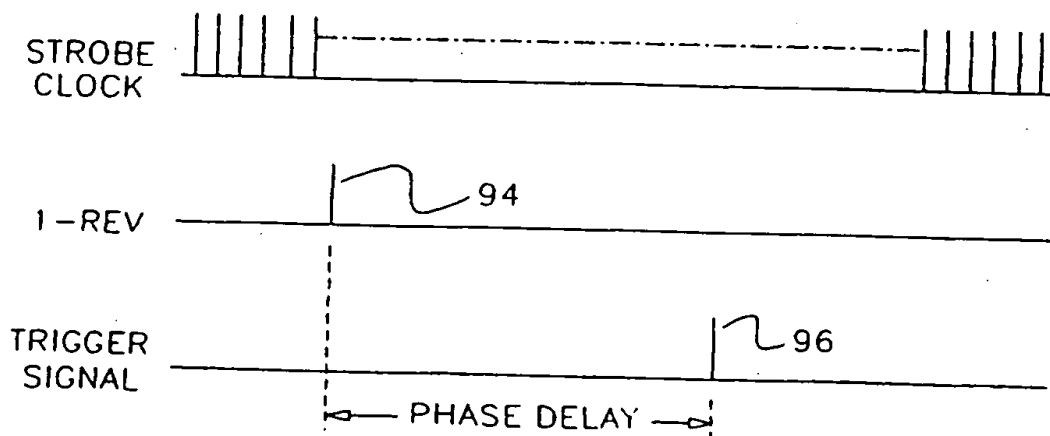


FIG-8



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/04805

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :B41C 1/04

US CL :358/299

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 358/299; 382/141; 356/378, 379; 364/474.35, 474.37

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS, search terms: engrav###, cylinder#, image#, strob###, camera, video, phase#, cell#, error#, calibrat###, video run length#

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y,P	US, A, 5,438,422 (HOLOWKO ET AL) 01 AUGUST 1995, see abstract and figure 1.	1-58
Y,P	US, A, 5,440,398 (HOLOWKO ET AL) 08 AUGUST 1995, see abstract and figure 1.	1-58

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier document published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

20 JUNE 1996

Date of mailing of the international search report

24 JUL 1996

Name and mailing address of the ISA/US
Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231

Facsimile No. (703) 305-3230

Authorized officer

for ERIC FRAHM

Telephone No. (703) 308 1783

Form PCT/ISA/210 (second sheet)(July 1992)*

THIS PAGE BLANK (USPTO)